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OIPE SEP 11 2000 PATENT & TRADEMARK OFFICE

FORM PTO-1390 (REV 12-29-99) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER T6637.CIP.PCT US
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/646235
INTERNATIONAL APPLICATION NO. PCT/US99/05710	INTERNATIONAL FILING DATE 15 March 1999	PRIORITY DATE CLAIMED 13 March 1998

TITLE OF INVENTION APPARATUS FOR CONVERTING OCEAN WAVE MOTION TO ELECTRICITY

APPLICANT(S) FOR DO/EO/US

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [ ] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [X] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [ ] Other items or information:

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U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/646235	PCT/US99/05710	T6637.CIP.PCT US

	CALCULATIONS	PTO USE ONLY
17. [X] The following fees are submitted: **BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):** Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .... **$970.00** International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO....... **$840.00** International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO .... **$690.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) .... **$670.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$96.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 96.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	23 - 20 =	3	X $18.00	$ 54.00	
Independent claims	2 - 3 =	0	X $78.00	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 280.00	
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$ 140.00	
SUBTOTAL =				$ 140.00	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ 0	
TOTAL NATIONAL FEE =				$ 140.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$ 140.00	
				Amount to be refunded:	$
				charged:	$

a. [X] A check in the amount of $ 140.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ______ in the amount of $______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 20-0100. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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27,930
REGISTRATION NUMBER

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PATENT APPLICATION 09/646,235
Attorney Docket No.: T6637.CIP.PCT.US

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

ART UNIT:

EXAMINER:

APPLICANT: North, et al

SERIAL NO.: 09/646,235

CONFRM. NO.:

FILED: March 15, 1999

FOR: APPARATUS FOR CONVERTING OCEAN WAVE MOTION TO ELECTRICITY

DOCKET NO.: T6637.CIP.PCT.US

PRELIMINARY AMENDMENT

VIA FAX TO (703) 746-6713

Francine Young
National Stage Processing
Paralegal Specialist

Dear Sir:

Please enter the following preliminary amendment in the pending application prior to examination of this patent application:

CERTIFICATE OF FACSIMILE TRANSMISSION §1.8

I hereby certify that this correspondence is being faxed to Francine Young, National Stage Processing, Paralegal Specialist at (703) 746-6713 on May 7, 2003.

Respectfully submitted,

Vaughn W. North

Vaughn W. North, Reg. 45,357

In the Specification:

Field of the Invention

The present invention relates to methods and devices for converting the energy from ocean or water waves to useful energy. More particularly, the present invention relates to the conversion of periodic wave motion present nearon beaches of the ocean to useful electrical energy.

Prior Art

Since the beginning of time, man has viewed the power of the oceans with awe and has long sought methods for harnessing this power for useful purposes. Perhaps one of the greatest forms of natural energy associated with the oceans is the recurring ~~tides and~~ resulting wavesaction that define the constantly changing boarders to these massive bodies of water. Powered by gravitational forces of the moon and changing weather conditions of wind, temperature and rain, the ever changing tides and ~~resulting~~ propagation of wave motion across the maj~~ority~~ of water surfaces of the earth generate an immeasurable force which continually pounds virtually every exposed shoreline of every continent of the world.

Attempts to tap this source of energy have experienced only nominal success. Whereas development of hydroelectric power sources on rivers has been a simple matter of applying a turbine to a moving stream of water, the capture of water movement of periodic waves has been a formidable challenge. Hundreds of devices have been contrived to directly respond to the ocean movements; however, few have survived the test of general commercial application. Typical approaches to this problem have included the use of tetheredmoving paddles, buoys and a myriad of other floating ~~or tethered~~ objects designed to move laterally with the currents in a rhythmic pattern, while transferring this energy to a mechanical linkage capable of generating electrical output.

A primary flaw in such systems arises from the surface location, or at least suspended linkage to surface structure, providing a dependence upon lateral interaction of moving mechanical parts with surface wave action to provide the medium of transfer of force from the oceans to a power generator. Such mechanical assemblies are not only expensive, but require regular maintenance and repair due to changing weather conditions at the surface, which are manifest in severe forces capable of crushing the strongest of structures. In addition, the constantly changing tides mandate complex height adjustment mechanisms to adjust to changing water levels. The resulting variations in operating conditions make it difficult to provide a single system that is capable of coping with the multitude of variables which must be satisfied in a surface-linked mechanical system of energy conversion.

What is needed is a power generation system ~~transfer medium~~ which operates in response to the periodic wave motion of the waters, but in a manner independent from other

REMARKS

In view of the extended period of time since the filing of this application, applicant has made a fresh review of its content and has identified numerous typographical errors. The changes to the specification have been provided in this amendment to correct these errors, as well as provide better consistency throughout the disclosure material. For example, references to "lateral" movement have been eliminated to avoid confusion with respect to lateral movement of a wave, but not necessarily lateral movement of the water. Those skilled in the art readily understand the dynamic action associated with waves occurring in the ocean; however, a casual reader may benefit from this clarification. Other changes have been made on a similar basis to developed enhanced consistency in the application, particularly with the claims.

Claim 1 has been amended to note that the power output occurs at the location of the transducer or pressure sensing structure on the ocean floor, a condition which was believed to be inherent in the claim scope, but for purposes of clarity, is properly set forth in an affirmative manner. Accordingly, it is believed that this amendment does not modify the scope of the original claim and is not submitted, therefore, as a limitation for purposes of patentability. Rather, applicant is making a good faith attempt to accelerate the prosecution of this application in view of its extended delay at the U. S. Patent and Trademark Office.

Claim 10 is amended to focus the claim of novelty to include the moveable head plate as a component of the transducer as described and shown.

Claims 11, 12, 13 and 19 include amendments to eliminate orientation limitations deemed unnecessary, thereby broadening the claims to a more accurate statement of the invention.

Claim 20 adds a limitation that the pressure sending structure is positioned at least five feet below the water level. This limitation is consistent with the disclosure on page 9, line 18 of the PCT application as filed.

The remaining amendments to original claims are typographical in nature and do not limit the scope of the originally defined invention, Accordingly, all claims are believed to be either broader or equal in scope to the originally filed claims, except for claim 22.

New claims 24 through 29 are drawn from the originally submitted claims and are likewise fully supported in the specification and drawings.

To further expedite examination of this application, applicant has included newly discovered art as identified in the accompanying Information Disclosure Statement. UK Patent Application GB 2282188 discloses an underwater device that operates along a changing depth or floor gradient. This device provides an array of chambers that operate to sequentially increase air pressure within the flexible chamber array. This pressurized air "is then passed to a high pressure air reservoir (not shown)" which is then available for conventional processing. Accordingly, this disclosure is for a device or method for

surface water conditions to produce electrical energy. The system must be economically feasible by favorably balancing cost of energy production versus kilowatt output.

Objects and Summary of the Invention

It is an object of the present invention to capture energy from recurring wave motion of water by indirect conversion of vertical motion to electrical power output.

It is a further object of the invention generate electrical power in response to changing weights of water over a fixed, submerged surface as a function of time.

Yet another object of this invention is to develop conversion of wave motion to electrical power without depending upon moving objects suspended within the water.

A still further object of this invention is the conversion of tidal energy and recurring wave motion to electrical energy indirectly based on changes in weight of the water as it flows onto and recedes from the beach in a recurring manner.

These and other objects are realized in a power transfer system which includes a pressure ~~or gravity sensing devices~~ transducer positioned at the ocean floor and under a location of wave movement configured for (i) registering changes in height of water in alternating crests and troughs above the pressure transducer~~sensing devices~~ and (ii) providing an electrical power output at the transducer corresponding to changes in force associated with the changes in the height of water. ~~A transfer medium is coupled at one end to the pressure sensing devices and extends to a second end at a shore location adjacent the location of wave movement for transmitting the power output of the pressure sensing devices to the shore location. A power conversion device such as an electric motor, light, bank of storage batteries or other useful electrical device is coupled to the transfer medium at the shore location for receiving the power output from the transfer medium and for processing the power output to electricity.~~ Other benefits and features will be apparent to those skilled in the art, based on the following detailed description, taken in combination with the accompanying drawings.

Description of the Drawings

Figure 1 graphically represents an array of pressure transducers coupled to a battery storage system, including access to utility power transfer lines.

Figure 2 represents a cross section of ocean beach which has been modified with a wave energy transfer system as shown in figure 1.

Figure 3 graphically illustrates a process for laying a grid of pressure transducers within a fluidized trench under the beach area of an ocean water source.

Figure 4 illustrates a mat of transducers secured to a rigid grid support for placement at the ocean floor, under several feet of sand, with a connecting wire for attachment to a power storage bank.

Figure 5 shows another embodiment of the present invention wherein electricity is developed by the relative movement of a magnet with respect to a coil, biased to a return position by a spring.

Figure 6 is a cross-section of figure 5, taken along the lines 6 - 6.

Figure 7 represents an additional embodiment using a piston configuration with leveraged force for conversion of linear motion to rotary motion in combination with a generator.

Figure 8 shows a perspective view of a billows device coupled to a rotary power conversion generator.

Figure 9 depicts a graphical cross-section of a lever arm powered by a billows device and coupled to linear electrical generator.

Figure 10 illustrates an additional embodiment of a magnet/coil generator in a mat.

Figure 11 shows a variation of the magnet/coil combination.

Detailed Description of the Invention

The present invention arises from the observation that indirect conversion of wave movement to electrical energy could avoid the mechanical limitations previously experienced with surface-linked paddles, wheels and floating systems. The challenge is how to capture the ~~lateral~~ movement of surface water in a reciprocating manner without being subject to physical wear or damage resulting from the sometimes violent thrust and receding movement of powerful ocean waves. Indeed, ~~the~~ a common perception within the prior art was to accept the limitation that conversion of the power of ocean tides and waves required a device that would respond to this ~~lateral~~ surface wave movement, and then convert this motion to rotary movement within a turbine or some other energy transfer medium. An inspection of the hundreds of devices and methods which have attempted to tap the ocean's energies quickly reveals this common paradigm.

The present invention adopts a new approach of indirect power conversion of surface wave action to an electro-mechanical transducer positioned on the ocean floor. Instead of focusing on the lateral movement of the ocean waters as the source of power, the new paradigm involves considering the vertical force applied by the ~~laterally~~ wave action of the moving waters. In simple terms, the invention arises with the observation that the ~~lateral~~ wave movement of water is accompanied by a change in water level at the surface, and an accompanying change in water depth. This variance in depth provides an immediate variation in weight, as recurring greater and lesser volumes of water ~~pass over~~ occur over any given area of submerged beach or ocean floor. In essence, the recurring rise and fall of water level can be viewed as a pumping mechanism which operates ~~independently~~ with normal damage associated with~~of~~ the severity of weather conditions at the ocean surface. Indeed, the more severe the weather and wave action is, the greater is the energy input to the ocean, leading to greater and more frequent variation in depth changes.

In basic terms, the present energy transfer system can be viewed as a column of water which varies in height in a recurring manner. This changing column of water possesses a gravitational force corresponding to the height of water above the ocean floor. The recurring waves constantly vary this height between the maximum height of any given wave and the lowest level water possible when the wave has receded. The difference in height represents an oscillating force and applied load (dependent upon the mass of the water) which can be directly converted~~transferred through a conversion medium~~ on the ocean floor to other forms of potential or kinetic energy. The recurring nature of this changing volume enables simulation of a pumping force, powered by gravity and developed indirectly by the wave action of the ocean.

Figure 1 illustrates ~~an indirect indirect~~ a conversion medium ~~which has no moving parts and is~~ substantially free from the direct surface movement associated with currents and tides. Here again, this aspect of the invention arises with the observation that power transfer from the recurring wave action can be realized below the water level, ~~under~~ at the ocean floor. This consideration requires an additional shift in paradigm to recognize that the sand base below the ocean water can be used as a pressure transfer medium for passing the changing load of the column of ocean water into a form of electrical energy within a somewhat protected environment, free from radical currents and possible attack of sea life. In fact, the fluid nature of sand and its excellent compaction characteristics provides an ideal medium for this energy transfer and conversion.

Accordingly, one embodiment of the present invention utilizes an array of pressure sensitive devices, such as piezoelectric pressure transducers 10, which are individually coupled to a conductive wire 11, which interfaces with a common conductor 12. This embodiment of the invention applies the capacity of piezoelectric material to convert an applied physical stress to voltage output. For example, numerous piezoelectric materials are known which are applied in microphone devices, stress meters, etc., which provide an analog output voltage proportional to the applied change in stress or loading. Typically, this voltage is used to measure changes in applied stress to a mechanical component and is coupled to a meter and associated circuitry to define an analog measurement of the applied load. In the present invention, the changing weight applied by the column of water can be used to develop a physical change on the piezoelectric material, resulting in a voltage output. This output voltage causes current flow along the coupled wires 11 and 12 to a battery storage unit 13. Electric power is stored in the battery based on the continual current flow supplied by the recurring wave action.

The mathematical relationship between current and applied load is dependent upon the specific piezoelectric material selected. Those skilled in the art of piezoelectric materials have developed representative constants e_i which predict the surface charge density of selected materials. Calculations based on the dimensions of the transducer

material and applied force demonstrate that current flow can be regularly pumped from a submerged array of transducers below a changing load supplied by wave action of the ocean. For example, it is estimated that a one square meter array of barium titanate having a thickness of one centimeter can supply up to .000013 amps with a changing applied force of one newton, based on the relationship:

$$\text{Current} = 0.000013 \times \text{Force}^2$$

Therefore, ten newtons can yield up to 1.3 ma of current. Although the current flow may be perceived as nominal, the ability to place thousands of transducer arrays which respond every few seconds with a new surge of current, when multiplied over years of maintenance free operation, can represent a significant source of energy. The use of battery storage units 14 permits the accumulation of such micro energy pulses to establish commercial applications for the energy conversion system. A diode gate 13 or other unidirectional current regulator provides a simple check against reverse drainage of power from the battery storage system 14. Appropriate connections can be made to a utility company 15 for power distribution to consumers 16.

Figure 2 graphically illustrates one embodiment of positioning such a transducer array below the sea bed or beach area 17. The array of transducer material 10 is positioned several feet below the transient surface of sand. Appropriate protective coatings such as polyurethane or some other material can be applied to minimize exposure to water. This location will typically be sufficiently close to the shore so that installation can be readily accomplished during low tide.

This material can be laid in long strips, with a common lead 11 being coupled to a single wire 12 which is connected to a battery storage unit 13 and buried a safe distance below ground.

Once in position, the transducer material remains static and should require little or no maintenance. Nevertheless, each few seconds brings a new wave 20, giving a rise in water level and attendant change in applied force. This pressure loads the transducer material, generating a pulse of current which is transmitted to the battery storage unit 13. The amount of current will depend upon the change of water level from peak or crest wave height 18 to trough level 19. This recurring shift every several seconds will continue to pump energy to the system for decades, with little additional expense beyond installation and initial cost of materials.

Figure 3 illustrates one method for positioning the subject invention at an operable location. First, a trench 41 is excavated along a section of ocean floor 17 below a region of ocean water 30 which is subject to constantly changing water elevations. A trenching device 40 travels along the ocean floor 12. The mat of transducers 10 is buried within the trench 41 at a depth which protects the transducer mat 10 from adverse exposure to ocean currents and sea life.

One method for excavating the disclosed trench 41 involves fluidizing sand and silt at the ocean floor 14 to form the trench as a liquid slurry. The transducer mat is laid within the fluidized sand and silt, which then is allowed to settle over and bury the transducer mat to a desired depth. The mat is then connected by means of a conductive wire 17 to the shoreline where it may be coupled to storage batteries or electrical devices. It will be apparent to those skilled in the art that numerous methods can be utilized to lay the transducer mat 10 at the ocean floor to establish a stable, stationary position with respect to the changing height of water overhead.

Figure 4 shows a mat of transducers 10 secured to a rigid grid support 40 for placement ~~a~~ at the ocean floor as illustrated above. A connecting wire 11 couples the respective transducers 10 to a power storage bank 14. The rigid grid support 40 supplies the stiffness for supporting the mat of transducers 10 as described above.

Other embodiments of the present invention representing a direct conversion of water force through a transducer on the ocean floor will be apparent to those skilled in the art from the following discussion. For example, Figure 5 depicts a graphic representation of a fully enclosed, submersible drum 50 which contains a moveable head plate 51 coupled to the combination of a coil 52 moving in a field of a magnet 53 or alternately, a magnet moving in a fixed coil. As overhead waves roll across the drum, the changing weight of overhead water exerts a changing gravity force F, which develops movement of the head plate 51 against the fixed resistance of a return biasing force such as springs 54. Phantom configuration lines 56 illustrates the displacement 57 of the head plate 51 under a wave peak overhead. As the following wave trough passes over, the gravity force F decreases to its minimum value and the restoring forces of the springs 54 displace the head plate 51 upward to the raised, rest position. The resulting relative reciprocating movement of the coil and magnet induces an electromotive force which generates voltage and current production, similar to the current output of the piezoelectric embodiment. The output and efficiency of this system, however, is significantly higher than that which could be supplied by currently known piezoelectric systems as described above.

Figures 5 and 6 further illustrate a displacement enhancement feature which converts the small displacement 57 of the head plate 51 to an increased displacement 58. This feature is enabled by use of a compression chamber 60 which has a fixed volume, except for the volume changes which result from displacement of the head plate 51 and a smaller, secondary plate 61. The smaller surface area of the secondary plate 61 results in substantially greater linear displacement 58 into a conversion chamber which allows the secondary plate to move in an unrestrained manner. This conversion chamber may be gas filled to protect electrical conversion components (magnets 63 and coil 62) from adverse contact with ocean water. The larger excursion path of the secondary plate 61 results in a corresponding enlarged path for the attached coil 62 through the magnetic field of magnet

63, leading to increased current production which is transmitted through attached lead 65 to the shoreline. A diode or rectifier bridge 55 rectifies polarities to provide continuous current flow to the battery system or electrical device 14.

The subject drum 50 may be made of concrete, plastic, ceramic, noncorrosive metals or other suitable materials which can withstand extended periods of submersion in ocean water. Preferable compositions should have sufficient density to overcome any buoyancy of the drum. Alternatively, securing loops 69 or other forms of anchoring means can be installed to enable secure fixation at the ocean floor. Concrete construction appears to offer the preferred density, as well as durability for extended life and reduced cost. Flexible surrounds 66 and 67 similar to speaker surrounds in audio products provide displacement capacity to the respective head plate 51 and secondary plate 61 while preserving a complete seal on the respective chambers. Once the conversion unit is fully assembled and sealed, a protective polymer coating or encasement 68 can be applied as a complete exterior seal. The device should therefore be able to operate for years without significant maintenance requirements.

Although a common fluid such as air may be preferred in the respective chambers to minimize differential compression rates when submerged, it is envisioned that the device will commonly be placed at lesser depths of water such as occur near the shoreline to maximize the relative change in gravity weight with each passing wave. Pressure influence at these levels should be nominal. Such shallow depths offer greater percentage variations in weight, which enable greater relative displacement of the coil and magnet. For example, a drum positioned under water at low tide may experience overhead waves of 3 to 10 feet in height. Assuming a depth of five feet for the head plate during a wave trough, the column height of overhead water will alternate between eight and fifteen feet. This is equivalent to a doubling of weight with every wave period. If high tide raises the water level another ten feet, then the height variation will range from eighteen to twenty-five feet, providing approximately a thirty percent variation in wave height. Moving the device to depths of 100 feet would quickly reduce the percent variation of weight and resulting displacement to a mere 5-6 percent. It will be apparent that actual design parameters will depend upon the unique characteristics of placement locations, anticipated ocean depths and relative water height variations. Resistive spring values for springs 54, plate dimensions, internal pressure levels, magnet and coil configuration and displacement ranges will require integration to maximize electrical output. With the explanation provided herein, these design considerations are well within the skill of the ordinary artisan.

Figure 7 illustrates an adaptation of the previous embodiment with linkage from a compression chamber 70 and head plate 71, through a piston member 73 to a lever arm 74. Similar principles of operation provide for displacement of the head plate 71 under changing gravity force F to a depressed position 75. This displacement is enhanced by the smaller

surface area of the piston 53, yielding greater linear movement as shown by phantom lines 76. Accordingly, the piston arm 77 drives the attached wheel 78 in rotation. Further enhancement of comparative head plate displacement is accomplished by reduction in diameter of drive wheel 79, which is attached to a rotary generator 80 which is axially coupled to the drive wheel 79. The occurrence of a wave trough allows the biasing springs 81 to return the head plate to an original raised position. Lead 82 couples the electrical output to a rectifier for processing the alternating signal to DC or rectified AC.

An additional embodiment of the present invention is shown in Figure 8. This device includes a bellows 85 with collapsible walls 86. A protective head plate 91 responds to changes in gravity force F based on the column weight of the overhead water. The return force may be contained air, a restoring spring, or a combination of both. The illustrated embodiment includes an axial rotation rod 87 rigidly coupled by braces 89 to the head plate 91 such that reciprocating movement of the bellows results in axial rotation of the rod 87. This rod is anchored along its rotational axis to a base plate 88 for structural alignment. One end of the rod 87 is coupled to a primary drive wheel 92, which is coupled to a secondary, smaller drive wheel 93 by a drive chain 94. The secondary drive wheel powers a rotary generator 96, which supplies alternating current to a rectifier 97 at a frequency corresponding to the periodicity of the wave action. The mechanical drive system is contained within a housing 98.

The same bellows of Figure 8 can be modified in Figure 9 for linear conversion of bellows movement to electrical output. In this version, the head plate 91 includes a lever arm 100 which is pivotally anchored to a fulcrum 101. As the bellows reciprocates in response to overhead wave action, the lever arm is raised and lowered. Displacement enhancement is provided by the longer section of lever arm 101a on the left side of the fulcrum. Accordingly, the remote end 102 of the lever arm moves along a larger vertical path than the bellows displacement. A harness 103 suspends a coil 104, which moves through a magnetic field generated by magnet 105, generating the desired current. A housing 106 protects the moving parts from the ocean environment.

The magnet and coil combination can also be embodied in a mat configuration, similar to that illustrated in Figure 4. For example, Figure 10 depicts an array of separate magnet/coil pods 110 which provide the relative magnet/coil movement in response to changing weight of the overhead water. Each pod is contained in a thin plastic housing 111 which seals the magnet 112 and coil 113 from corrosive action of the sea water. A spring mechanism 114 biases the magnet 112 in a raised position, yet has sufficiently low stiffness to allow the supported magnet 112 to readily depress under increasing weight of a rising wave crest overhead. Current from the coil is transmitted by a connecting wire 118. The thin plastic housing is sufficiently loose around the coil to permit the magnet to easily displace within the volume enclosed by the coil. The coil may actually be encased in a rigid

plastic wall (phantom lines 115) to retain fixed coil orientation as the magnet reciprocates with the wave action. A stiff support plate 116 provides resistance against vertical movement of the spring mechanism, and may be further supported by a rigid base 117. A surrounding mat 119 retains the array of pods in place. It will be apparent that the number of pods in an actual mat configuration would be much greater in density to maximize current generation from overhead wave action.

An additional modification of the magnet/coil combination is shown in Figure 11, wherein the spring means for movably supporting the magnet is the coil itself. A base plate 120 supports a magnet 121 within the field volume of the coil 122 and in fixed position. The coil 122 contracts periodically in response to the force F applied to a head plate 123, causing the required relative movement of the coil with respect to the magnet 121. This embodiment offers some advantage in simplicity and cost reduction; however, sacrifices some strength of field interaction in view of limited movement of the coil. By using large arrays of super-magnets (neodinium magnets) having extreme high field strength, sufficient current can be generated for a workable system.

It is to be understood that the numerous disclosed embodiments are provided to illustrate the broad inventive principles of this invention and are not intended to be limiting, except by the following claims.

In the Claims:

CLAIMS

I claim:

1. (currently amended) A power transfer system for converting recurring wave movement within the ocean to electrical energy, said system comprising:

pressure sensing structure positioned at a stationary location at an ocean floor below water level and below a location of wave movement for (i) registering changes in height of water above the pressure sensing structure and (ii) providing an electrical power output at the ocean floor location corresponding to changes in force associated with the changes in the height of water;

a transfer medium coupled at one end to the pressure sensing structure and extending along the ocean floor to a second end at a shore location adjacent the location of wave movement, said transfer medium including means for transmitting the electrical power output of the pressure sensing structure to the shore location; and

electrical power receiving means coupled to the transfer medium at the shore location for receiving the electrical power output from the transfer medium and for processing the electrical power output to a useful form of energy.

2. (original) A power transfer system as defined in claim 1, wherein the pressure sensing structure comprises a pressure transducer which responds to changes in pressure of water and supplies the electrical power output as an output voltage.

3. (original) A power transfer system as defined in claim 2, wherein the pressure transducer comprises a piezoelectric material which responds to changes in pressure to produce the electrical power output, said transfer medium comprising a conductive material connected at one end to the pressure transducer and at the other end to the power receiving means.

4. (original) A power transfer system as defined in claim 1, wherein the pressure sensing structure comprises an interconnected array of pressure transducers including an output connection coupled to the power transfer medium.

5. (original) A power transfer system as defined in claim 4, wherein the array of pressure transducers are interconnected in parallel relationship to an output connection which cumulates voltage output from individual pressure transducers for transmission to the transfer medium.

6. (original) A power transfer system as defined in claim 2, wherein the power receiving means comprises a battery storage system for storing electrical energy received from the output voltage.

7. (original). A power transfer system as defined in claim 3, wherein the array of transducers are buried within a section of ocean floor at sufficient depth to be substantially undisturbed by currents and sea life.

8. (original) A power transfer system as defined in claim 7, wherein the transfer medium comprises connecting wire at the ocean floor between the array of transducers and the power receiving means.

9. (original) A power transfer system as defined in claim 3, wherein the array of pressure transducers comprises a mat of interconnected pressure transducers and connecting wires, said mat including a common output lead coupled to the transfer medium.

10. (currently amended) A power transfer system as defined in claim 2, wherein the pressure transducer includes:

a combination coil and magnet in relative movable relationship;

a moveable head plate coupled to the combination coil and magnet and being configured to respond directly to the changes in ~~weight of~~ water pressure at the head plate ~~overhead~~ to ~~vertically~~ displace and induce movement within the relative movable relationship of the coil and magnet for activating a current within the coil; and

restoring means coupled to the head plate for periodically ~~elevating~~ restoring the head plate to a ~~rest~~ position during a trough of the overhead wave in preparation for a following ~~downward~~ displacement responsive to increased ~~weight of~~ water pressure at the head plate generated by a following wave crest.

11. (currently amended) A power transfer system as defined in claim 10, further comprising a secondary plate movably coupled with the head plate and being configured to amplify any ~~vertical~~ displacement of the head plate with increased displacement of the secondary plate with an attendant increased current output from the coil.

12. (currently amended) A power transfer system as defined in claim 11, further including:

a compression chamber bounded at an ~~upper~~ opening by the movable head plate;

the secondary plate forming a movable surface which is coupled at one side to the compression chamber and movably positioned at an opposing side within a conversion chamber of lesser diameter than the compression chamber and along an axial orientation of displacement;

said compression chamber having a fluid content which transfers force applied to the head plate into the secondary plate in response to displacement of the head plate and causes a volume displacement of the secondary plate within the conversion chamber;

saaid secondary plate having a lesser surface area than the head plate to cause increased linear displacement of the secondary plate as compared with displacement of the head plate;

said secondary plate being coupled to the combination of coil and magnet to translate said linear displacement into relative movement of the coil and magnet to generate the current within the coil.

13. (currently amended) A power transfer system as defined in claim 14, wherein the ~~secondary plate~~ pressure sensing structure comprises a rotary plate coupled to a generator at a rotational axis~~, said system further including intermediate power transmission structure for translating vertical displacement of the head plate into rotational displacement of the rotary plate~~.

14. (original) A power transfer system as defined in claim 1, wherein the pressure sensing structure comprises a combination of magnet and coil which are positioned to develop an interacting relationship within a magnetic field of the magnet and with respect to the coil, the combination of magnet and coil being movable with respect to each other in response to the changing height and weight of water to thereby generate an electrical current within the coil, said coil being coupled to the power transfer system for delivering the electrical power output.

15. (original) A power transfer system as defined in claim 1, wherein the pressure sensing structure includes:

a combination of magnet and coil in relative movable relationship for generating current within the coil;

a bellows having a movable plate and a stationary plate and a sealed compression chamber there between, said movable plate being coupled to the combination of magnet and coil and including a power transmission structure to translate plate movement to the relative movement of the magnet and coil;

said movable plate being depressible by an increased column height of water over the movable plate and including a restoring means for elevating the movable plate to a raised, rest position in response to lesser overhead water to generate a pumping action.

16. (original) A power transfer system as defined in claim 1, wherein the power transmission structure includes a lever arm coupled at one end to the pressure sensing structure and at a remaining end to the combination of magnet and coil and including a fulcrum point which provides an increased range of motion for the combination magnet and coil as compared to the end coupled to the pressure sensing structure to increase a range of motion of relative movement between the coil and magnet.

17. (original) A power transfer system as defined in claim 10, wherein the coil is in fixed position and the magnet moves with respect to the coil.

18. (original) A power transfer system as defined in claim 10, wherein the magnet is in fixed position and the coil moves with respect to the magnet.

19. (currently amended) A power transfer system as defined in claim 1, wherein the pressure sensing structure includes:

a housing;

a head plate movably positioned at the ~~top of the~~ housing, said head plate being supported in a movable configuration responsive to changing weight of overhead water based on the wave motion;

a ~~spring mechanism~~ resistive force coupled to the head plate for restoring the head plate position ~~upward~~ following depression in response to an overhead wave; and

a combination magnet and coil interactively coupled to the head plate and within an attendant magnetic field such that movement of the head plate results in relative movement between the magnet and coil within the magnetic field to generate current within the coil.

20. (currently amended) A power transfer system as defined in claim 17, wherein the coil also comprises ~~the~~ a spring mechanism for providing the resistive force, said magnet being supported within an internal volume of the coil and operable to generate a current within the coil based upon depression of the coil by the overhead wave and concurrent movement of the magnet within the coil.

21. (original) A power transfer system as defined in claim 1, including:

a base plate;

at least one permanent magnet having a plate-like configuration;

a spring mechanism positioned below the magnet and supported by the base plate, said spring mechanism providing a resistive force to support the magnet below a column of water; and

a conductive coil positioned around the magnet and within an attendant magnetic field;

the magnet, coil and spring mechanism be positioned and supported at the base plate to provide oscillating relative movement of the magnet with respect to the coil to generate an electrical current in response to overhead wave action.

22. (currently amended) A method for converting recurring wave movement within the ocean to useful energy, said method comprising the steps of:

a) positioning pressure sensing structure at least five feet below water level and at an ocean floor location; and

b) generating electrical power output from the pressure sensing structure at the ocean floor location by direct electro-mechanical conversion of gravity force arising from changes in height of water between a wave crest and trough above the pressure sensing structure to electrical current at the ocean floor location~~; and~~

~~c) transferring the electrical power output to a shore location.~~

23. (currently amended) ~~23.~~ A method as defined in claim 22~~0~~, further comprising the step of generating current flow by causing relative movement of a magnet and field

coil positioned at the ocean floor in response to changes in the force~~weight~~ of overhead water above the pressure sensitive structure.

24. (new) A method as defined in claim 22, further comprising the step of transferring the electrical power output to a shore location.

25. (new) A method as defined in claim 23, wherein the generating step comprises the more specific step of rotationally displacing a plate member to apply rotational force to an electro-mechanical conversion device.

26. (new) A power transfer system for converting recurring wave movement within the ocean to electrical energy, said system comprising at least one pressure transducer positioned at a stationary location at an ocean floor at least five feet below water level and below a location of wave movement configured for (i) registering changes in height of water at alternating crests and troughs above the pressure sensing structure and (ii) providing direct electrical power output at the transducer corresponding to changes in force associated with the alternating crests and troughs.

27. (new) A system as defined in claim 26, further comprising a transfer medium coupled at one end to the pressure sensing structure for receiving electrical power and at an opposing end to an electrically powered device.

28. (new) A system as defined in claim 27, wherein the electrically powered device comprises a battery pack.

29. (new) A system as defined in claim 27, wherein the transfer medium comprises a conducting wire extending along the ocean floor to a shore location.

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In the Abstract:

~~ABSTRACT~~ ABSTRACT OF THE DISCLOSURE

A power transfer system for converting recurring wave movement within the ocean to electrical energy. The system comprises pressure sensing structure such as a pressure transducer 10 or combination movable magnet and coil 50, positioned below water level and at a location 20 of wave movement for (i) registering changes in height of water 18 and 19 above the pressure sensing structure 10, 50 and (ii) providing electrical power output at the ocean floor corresponding to changes in gravity force associated with the changes in the height of water. A transfer medium 12 is coupled at one end to the pressure sensing structure and extends at a second end to a shore location. A power receiving device such as a bank of storage batteries 14 or electrical load is coupled to the transfer medium at the shore location for receiving the power output from the transfer medium and for processing the power for use.

conventional processing. Accordingly, this disclosure is for a device or method for producing a pressurized tank of air, not for generating electrical output at the transducer on the ocean floor. See page 4, line 34. Examples for use of pressurized air are set forth on page 2, lines 20 to 24, stating, "Such compressed air may be utilized(sic) to raise water to a high level water reservoir, for example with peristaltic pipes and may then be utilized for the generation of electricity by conventional hydroelectric means." Clearly, this disclosure does not suggest the claimed invention of providing electrical power output at the ocean floor.

The second reference is Japanese application 10103215. This reference discloses a piezoelectric element carried in a housing having "a wave receiving plate which receives waves on the principal plane." Page 1, claim 1. This is described as a spherical concave, presumably configured to reduce the escape of waves as they impact the plate. Page 2, paragraph 21. In other words, this device is apparently positioned on the beach where tumbling waves fall on the plate with direct impact, distorting the piezo element for power generation. Applicant submits that the reference is so indefinite that a clear understanding of how this invention works is impossible. Therefore, its applicability to the present invention is dubious. Nevertheless, the conjecture offered above is at least sufficient to show that the Japanese disclosure does not operate in accordance with the presently claimed invention, because it is not responding to a pressure differential generated by the crest and trough of an ocean wave. Clearly, this device would not be placed a depths greater that five feet, but would instead be positioned at actual wave level to enable direct impact.

In view of the comments in this amendment, applicant submits that the present claims are in condition for allowance and requests favorable action as soon as possible. If there are any questions or concerns regarding this Preliminary Amendment and contents thereof, the Examiner is invited to call the undersigned.

The Commissioner is hereby authorized to charge any additional fee or to credit any overpayment in connection with this Preliminary Amendment to Deposit Account No. 20-0100.

DATED this 7th day of May 2003.

Respectfully submitted,

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APPARATUS FOR CONVERTING OCEAN WAVE MOTION TO ELECTRICITY

Background of the Invention

Field of the Invention

The present invention relates to methods and devices for converting the energy from ocean or water waves to useful energy. More particularly, the present invention relates to the conversion of period wave motion present on beaches of the ocean to useful electrical energy.

Prior Art

Since the beginning of time, man has viewed the power of the oceans with awe and has long sought methods for harnessing this power for useful purposes. Perhaps one of the greatest forms of natural energy associated with the oceans is the recurring tides and resulting waves that define the constantly changing boarders to these massive bodies of water. Powered by gravitational forces of the moon and changing weather conditions of wind, temperature and rain, the ever changing tides and resulting propagation of wave motion across the majority of surface of the earth generate an immeasurable force which continually pounds virtually every exposed shoreline of every continent of the world.

Attempts to tap this source of energy have experienced only nominal success. Whereas development of hydroelectric power sources on rivers has been a simple matter of applying a turbine to a moving stream of water, the capture of water movement of periodic waves has been a formidable challenge. Hundreds of devices have been contrived to directly respond to the ocean movements; however, few have survived the test of general commercial application. Typical approaches to this problem have included the use of moving paddles, buoys and a myriad of other floating or tethered objects designed to move laterally with the currents in a rhythmic pattern, while transferring this energy to a mechanical linkage capable of generating electrical output.

A primary flaw in such systems arises from the surface location, or at least suspended linkage to surface structure, providing a dependence upon lateral interaction of moving mechanical parts with surface wave action to provide the medium of transfer of force from the oceans to a power generator. Such mechanical assemblies are not only expensive, but require regular maintenance and

repair due to changing weather conditions at the surface, which are manifest in severe forces capable of crushing the strongest of structures. In addition, the constantly changing tides mandate complex height adjustment mechanisms to adjust to changing water levels. The resulting variations in operating conditions make it difficult to provide a single system that is capable of coping with the multitude of variables which must be satisfied in a surface-linked mechanical system of energy conversion.

What is needed is a transfer medium which operates in response to the periodic wave motion of the waters, but in a manner independent from other surface water conditions to produce electrical energy. The system must be economically feasible by favorably balancing cost of energy production versus kilowatt output.

Objects and Summary of the Invention

It is an object of the present invention to capture energy from recurring wave motion of water by indirect conversion of vertical motion to electrical power output.

It is a further object of the invention generate electrical power in response to changing weights of water over a fixed, submerged surface as a function of time.

Yet another object of this invention is to develop conversion of wave motion to electrical power without depending upon moving objects suspended within the water.

A still further object of this invention is the conversion of tidal energy and recurring wave motion to electrical energy indirectly based on changes in weight of the water as it flows onto and recedes from the beach in a recurring manner.

These and other objects are realized in a power transfer system which includes pressure or gravity sensing devices positioned at the ocean floor and under a location of wave movement for (i) registering changes in height of water above the pressure sensing devices and (ii) providing a power output corresponding to changes in force associated with the changes in the height of water. A transfer medium is coupled at one end to the pressure sensing devices and extends to a second end at a shore location adjacent the location of wave

movement for transmitting the power output of the pressure sensing devices to the shore location. A power conversion device such as an electric motor, light, bank of storage batteries or other useful electrical device is coupled to the transfer medium at the shore location for receiving the power output from the transfer medium and for processing the power output to electricity. Other benefits and features will be apparent to those skilled in the art, based on the following detailed description, taken in combination with the accompanying drawings.

Description of the Drawings

Figure 1 graphically represents an array of pressure transducers coupled to a battery storage system, including access to utility power transfer lines.

Figure 2 represents a cross section of ocean beach which has been modified with a wave energy transfer system as shown in figure 1.

Figure 3 graphically illustrates a process for laying a grid of pressure transducers within a fluidized trench under the beach area of an ocean water source.

Figure 4 illustrates a mat of transducers secured to a rigid grid support for placement at the ocean floor, under several feet of sand, with a connecting wire for attachment to a power storage bank.

Figure 5 shows another embodiment of the present invention wherein electricity is developed by the relative movement of a magnet with respect to a coil, biased to a return position by a spring.

Figure 6 is a cross-section of figure 5, taken along the lines 6 - 6.

Figure 7 represents an additional embodiment using a piston configuration with leveraged force for conversion of linear motion to rotary motion in combination with a generator.

Figure 8 shows a perspective view of a billows device coupled to a rotary power conversion generator.

Figure 9 depicts a graphical cross-section of a lever arm powered by a billows device and coupled to linear electrical generator.

Figure 10 illustrates an additional embodiment of a magnet/coil generator in a mat.

Figure 11 shows a variation of the magnet/coil combination.

Detailed Description of the Invention

The present invention arises from the observation that indirect conversion of wave movement to electrical energy could avoid the mechanical limitations previously experienced with surface-linked paddles, wheels and floating systems. The challenge is how to capture the lateral movement of surface water in a reciprocating manner without being subject to physical wear or damage resulting from the sometimes violent thrust and receding movement of powerful ocean waves. Indeed, the perception within the prior art was to accept the limitation that conversion of the power of ocean tides and waves required a device that would respond to this lateral wave movement, and then convert this motion to rotary movement within a turbine or some other energy transfer medium. An inspection of the hundreds of devices and methods which have attempted to tap the ocean's energies quickly reveals this common paradigm.

The present invention adopts a new approach of indirect power conversion. Instead of focusing on the lateral movement of the ocean waters as the source of power, the new paradigm involves considering the vertical force applied by the laterally moving waters. In simple terms, the invention arises with the observation that the lateral movement of water is accompanied by a change in water level at the surface, and an accompanying change in water depth. This variance in depth provides an immediate variation in weight, as recurring greater and lesser volumes of water pass over any given area of submerged beach or ocean floor. In essence, the recurring rise and fall of water level can be viewed as a pumping mechanism which operates independently of the severity of weather conditions at the ocean surface. Indeed, the more severe the weather and wave action is, the greater is the energy input to the ocean, leading to greater and more frequent variation in depth changes.

In basic terms, the present energy transfer system can be viewed as a column of water which varies in height in a recurring manner. This changing column of water possesses a gravitational force corresponding to the height of water above the ocean floor. The recurring waves constantly vary this height between the maximum height of any given wave and the lowest level water possible when the wave has receded. The difference in height represents an

oscillating force and applied load (dependent upon the mass of the water) which can be transferred through a conversion medium on the ocean floor to other forms of potential or kinetic energy. The recurring nature of this changing volume enables simulation of a pumping force, powered by gravity and developed indirectly by the wave action of the ocean.

Figure 1 illustrates an indirect conversion medium which has no moving parts and is substantially free from the direct movement associated with currents and tides. Hereagain, this aspect of the invention arises with the observation that power transfer from the recurring wave action can be realized below the water level, under the ocean floor. This consideration requires an additional shift in paradigm to recognize that the sand base below the ocean water can be used as a pressure transfer medium for passing the changing load of the column of ocean water into a form of electrical energy within a somewhat protected environment, free from radical currents and possible attack of sea life. In fact, the fluid nature of sand and its excellent compaction characteristics provides an ideal medium for this energy transfer and conversion.

Accordingly, one embodiment of the present invention utilizes an array of pressure sensitive devices, such as piezoelectric pressure transducers 10, which are individually coupled to a conductive wire 11, which interfaces with a common conductor 12. This embodiment of the invention applies the capacity of piezoelectric material to convert an applied physical stress to voltage output. For example, numerous piezoelectric materials are known which are applied in microphone devices, stress meters, etc., which provide an analog output voltage proportional to the applied change in stress or loading. Typically, this voltage is used to measure changes in applied stress to a mechanical component and is coupled to a meter and associated circuitry to define an analog measurement of the applied load. In the present invention, the changing weight applied by the column of water can be used to develop a physical change on the piezoelectric material, resulting in a voltage output. This output voltage causes current flow along the coupled wires 11 and 12 to a battery storage unit 13. Electric power is stored in the battery based on the continual current flow supplied by the recurring wave action.

The mathematical relationship between current and applied load is dependent upon the specific piezoelectric material selected. Those skilled in the art of piezoelectric materials have developed representative constants e_i which predict the surface charge density of selected materials. Calculations based on the dimensions of the transducer material and applied force demonstrate that current flow can be regularly pumped from a submerged array of transducers below a changing load supplied by wave action of the ocean. For example, it is estimated that a one square meter array of barium titanate having a thickness of one centimeter can supply up to .000013 amps with a changing applied force of one newton, based on the relationship:

$$\text{Current} = 0.000013 \times \text{Force}^2$$

Therefore, ten newtons can yield up to 1.3 ma of current. Although the current flow may be perceived as nominal, the ability to place thousands of transducer arrays which respond every few seconds with a new surge of current, when multiplied over years of maintenance free operation, can represent a significant source of energy. The use of battery storage units 14 permits the accumulation of such micro energy pulses to establish commercial applications for the energy conversion system. A diode gate 13 or other unidirectional current regulator provides a simple check against reverse drainage of power from the battery storage system 14. Appropriate connections can be made to a utility company 15 for power distribution to consumers 16.

Figure 2 graphically illustrates one embodiment of positioning such a transducer array below the sea bed or beach area 17. The array of transducer material 10 is positioned several feet below the transient surface of sand. Appropriate protective coatings such as polyurethane or some other material can be applied to minimize exposure to water. This location will typically be sufficiently close to the shore so that installation can be readily accomplished during low tide.

This material can be laid in long strips, with a common lead 11 being coupled to a single wire 12 which is connected to a battery storage unit 13 and buried a safe distance below ground.

Once in position, the transducer material remains static and should require little or no maintenance. Nevertheless, each few seconds brings a new wave 20, giving a rise in water level and attendant change in applied force. This pressure loads the transducer material, generating a pulse of current which is transmitted to the battery storage unit 13. The amount of current will depend upon the change of water level from peak wave height 18 to trough level 19. This recurring shift every several seconds will continue to pump energy to the system for decades, with little additional expense beyond installation and initial cost of materials.

Figure 3 illustrates one method for positioning the subject invention at an operable location. First, a trench 41 is excavated along a section of ocean floor 17 below a region of ocean water 30 which is subject to constantly changing water elevations. A trenching device 40 travels along the ocean floor 12. The mat of transducers 10 is buried within the trench 41 at a depth which protects the transducer mat 10 from adverse exposure to ocean currents and sea life.

One method for excavating the disclosed trench 41 involves fluidizing sand and silt at the ocean floor 14 to form the trench as a liquid slurry. The transducer mat is laid within the fluidized sand and silt, which then is allowed to settle over and bury the transducer mat to a desired depth. The mat is then connected by means of a conductive wire 17 to the shoreline where it may be coupled to storage batteries or electrical devices. It will be apparent to those skilled in the art that numerous methods can be utilized to lay the transducer mat 10 at the ocean floor to establish a stable, stationary position with respect to the changing height of water overhead.

Figure 4 shows a mat of transducers 10 secured to a rigid grid support 40 for placement a the ocean floor as illustrated above. A connecting wire 11 couples the respective transducers 10 to a power storage bank 14. The rigid grid support 40 supplies the stiffness for supporting the mat of transducers 10 as described above.

Other embodiments of the present invention will be apparent to those skilled in the art. For example, Figure 5 depicts a graphic representation of a fully enclosed, submersible drum 50 which contains a moveable head plate 51 coupled to the combination of a coil 52 moving in a field of a magnet 53 or alternately, a

magnet moving in a fixed coil. As overhead waves roll across the drum, the changing weight of overhead water exerts a changing gravity force F, which develops movement of the head plate 51 against the fixed resistance of a return biasing force such as springs 54. Phantom configuration lines 56 illustrates the displacement 57 of the head plate 51 under a wave peak overhead. As the following wave trough passes over, the gravity force F decreases to its minimum value and the restoring forces of the springs 54 displace the head plate 51 upward to the raised, rest position. The resulting relative reciprocating movement of the coil and magnet induces an electromotive force which generates voltage and current production, similar to the current output of the piezoelectric embodiment. The output and efficiency of this system, however, is significantly higher than that which could be supplied by currently known piezoelectric systems as described above.

Figures 5 and 6 further illustrate a displacement enhancement feature which converts the small displacement 57 of the head plate 51 to an increased displacement 58. This feature is enabled by use of a compression chamber 60 which has a fixed volume, except for the volume changes which result from displacement of the head plate 51 and a smaller, secondary plate 61. The smaller surface area of the secondary plate 61 results in substantially greater linear displacement 58 into a conversion chamber which allows the secondary plate to move in an unrestrained manner. This conversion chamber may be gas filled to protect electrical conversion components (magnets 63 and coil 62) from adverse contact with ocean water. The larger excursion path of the secondary plate 61 results in a corresponding enlarged path for the attached coil 62 through the magnetic field of magnet 63, leading to increased current production which is transmitted through attached lead 65 to the shoreline. A diode or rectifier bridge 55 rectifies polarities to provide continuous current flow to the battery system or electrical device 14.

The subject drum 50 may be made of concrete, plastic, ceramic, noncorrosive metals or other suitable materials which can withstand extended periods of submersion in ocean water. Preferable compositions should have sufficient density to overcome any buoyancy of the drum. Alternatively, securing

loops 69 or other forms of anchoring means can be installed to enable secure fixation at the ocean floor. Concrete construction appears to offer the preferred density, as well as durability for extended life and reduced cost. Flexible surrounds 66 and 67 similar to speaker surrounds in audio products provide displacement capacity to the respective head plate 51 and secondary plate 61 while preserving a complete seal on the respective chambers. Once the conversion unit is fully assembled and sealed, a protective polymer coating or encasement 68 can be applied as a complete exterior seal. The device should therefore be able to operate for years without significant maintenance requirements.

Although a common fluid such as air may be preferred in the respective chambers to minimize differential compression rates when submerged, it is envisioned that the device will commonly be placed at lesser depths of water such as occur near the shoreline to maximize the relative change in gravity weight with each passing wave. Pressure influence at these levels should be nominal. Such shallow depths offer greater percentage variations in weight, which enable greater relative displacement of the coil and magnet. For example, a drum positioned under water at low tide may experience overhead waves of 3 to 10 feet in height. Assuming a depth of five feet for the head plate during a wave trough, the column height of overhead water will alternate between eight and fifteen feet. This is equivalent to a doubling of weight with every wave period. If high tide raises the water level another ten feet, then the height variation will range from eighteen to twenty-five feet, providing approximately a thirty percent variation in wave height. Moving the device to depths of 100 feet would quickly reduce the percent variation of weight and resulting displacement to a mere 5-6 percent. It will be apparent that actual design parameters will depend upon the unique characteristics of placement locations, anticipated ocean depths and relative water height variations. Resistive spring values for springs 54, plate dimensions, internal pressure levels, magnet and coil configuration and displacement ranges will require integration to maximize electrical output. With the explanation provided herein, these design considerations are well within the skill of the ordinary artisan.

Figure 7 illustrates an adaptation of the previous embodiment with linkage from a compression chamber 70 and head plate 71, through a piston member 73 to

a lever arm 74. Similar principles of operation provide for displacement of the head plate 71 under changing gravity force F to a depressed position 75. This displacement is enhanced by the smaller surface area of the piston 53, yielding greater linear movement as shown by phantom lines 76. Accordingly, the piston arm 77 drives the attached wheel 78 in rotation. Further enhancement of comparative head plate displacement is accomplished by reduction in diameter of drive wheel 79, which is attached to a rotary generator 80 which is axially coupled to the drive wheel 79. The occurrence of a wave trough allows the biasing springs 81 to return the head plate to an original raised position. Lead 82 couples the electrical output to a rectifier for processing the alternating signal to DC or rectified AC.

An additional embodiment of the present invention is shown in Figure 8. This device includes a bellows 85 with collapsible walls 86. A protective head plate 91 responds to changes in gravity force F based on the column weight of the overhead water. The return force may be contained air, a restoring spring, or a combination of both. The illustrated embodiment includes an axial rotation rod 87 rigidly coupled by braces 89 to the head plate 91 such that reciprocating movement of the bellows results in axial rotation of the rod 87. This rod is anchored along its rotational axis to a base plate 88 for structural alignment. One end of the rod 87 is coupled to a primary drive wheel 92, which is coupled to a secondary, smaller drive wheel 93 by a drive chain 94. The secondary drive wheel powers a rotary generator 96, which supplies alternating current to a rectifier 97 at a frequency corresponding to the periodicity of the wave action. The mechanical drive system is contained within a housing 98.

The same bellows of Figure 8 can be modified in Figure 9 for linear conversion of bellows movement to electrical output. In this version, the head plate 91 includes a lever arm 100 which is pivotally anchored to a fulcrum 101. As the bellows reciprocates in response to overhead wave action, the lever arm is raised and lowered. Displacement enhancement is provided by the longer section of lever arm 101a on the left side of the fulcrum. Accordingly, the remote end 102 of the lever arm moves along a larger vertical path than the bellows displacement. A harness 103 suspends a coil 104, which moves through a

magnetic field generated by magnet 105, generating the desired current. A housing 106 protects the moving parts from the ocean environment.

The magnet and coil combination can also be embodied in a mat configuration, similar to that illustrated in Figure 4. For example, Figure 10 depicts an array of separate magnet/coil pods 110 which provide the relative magnet/coil movement in response to changing weight of the overhead water. Each pod is contained in a thin plastic housing 111 which seals the magnet 112 and coil 113 from corrosive action of the sea water. A spring mechanism 114 biases the magnet 112 in a raised position, yet has sufficiently low stiffness to allow the supported magnet 112 to readily depress under increasing weight of a rising wave crest overhead. Current from the coil is transmitted by a connecting wire 118. The thin plastic housing is sufficiently loose around the coil to permit the magnet to easily displace within the volume enclosed by the coil. The coil may actually be encased in a rigid plastic wall (phantom lines 115) to retain fixed coil orientation as the magnet reciprocates with the wave action. A stiff support plate 116 provides resistance against vertical movement of the spring mechanism, and may be further supported by a rigid base 117. A surrounding mat 119 retains the array of pods in place. It will be apparent that the number of pods in an actual mat configuration would be much greater in density to maximize current generation from overhead wave action.

An additional modification of the magnet/coil combination is shown in Figure 11, wherein the spring means for movably supporting the magnet is the coil itself. A base plate 120 supports a magnet 121 within the field volume of the coil 122 and in fixed position. The coil 122 contracts periodically in response to the force F applied to a head plate 123, causing the required relative movement of the coil with respect to the magnet 121. This embodiment offers some advantage in simplicity and cost reduction; however, sacrifices some strength of field interaction in view of limited movement of the coil. By using large arrays of super-magnets (neodinium magnets) having extreme high field strength, sufficient current can be generated for a workable system.

CLAIMS

I claim:

1. A power transfer system for converting recurring wave movement within the ocean to electrical energy, said system comprising:

pressure sensing structure positioned at a stationary location at an ocean floor below water level and below a location of wave movement for (i) registering changes in height of water above the pressure sensing structure and (ii) providing an electrical power output corresponding to changes in force associated with the changes in the height of water;

a transfer medium coupled at one end to the pressure sensing structure and extending along the ocean floor to a second end at a shore location adjacent the location of wave movement, said transfer medium including means for transmitting the electrical power output of the pressure sensing structure to the shore location; and

electrical power receiving means coupled to the transfer medium at the shore location for receiving the electrical power output from the transfer medium and for processing the electrical power output to a useful form of energy.

2. A power transfer system as defined in claim 1, wherein the pressure sensing structure comprises a pressure transducer which responds to changes in pressure and supplies the electrical power output as an output voltage.

3. A power transfer system as defined in claim 2, wherein the pressure transducer comprises a piezoelectric material which responds to changes in pressure to produce the electrical power output, said transfer medium comprising a conductive material connected at one end to the pressure transducer and at the other end to the power receiving means.

4. A power transfer system as defined in claim 1, wherein the pressure sensing structure comprises an interconnected array of pressure transducers including an output connection coupled to the power transfer medium.

5. A power transfer system as defined in claim 4, wherein the array of pressure transducers are interconnected in parallel relationship to an output connection which cumulates voltage output from individual pressure transducers for transmission to the transfer medium.

6. A power transfer system as defined in claim 2, wherein the power receiving means comprises a battery storage system for storing electrical energy received from the output voltage.

7. A power transfer system as defined in claim 3, wherein the array of transducers are buried within a section of ocean floor at sufficient depth to be substantially undisturbed by currents and sea life.

8. A power transfer system as defined in claim 7, wherein the transfer medium comprises connecting wire at the ocean floor between the array of transducers and the power receiving means.

9. A power transfer system as defined in claim 3, wherein the array of pressure transducers comprises a mat of interconnected pressure transducers and connecting wires, said mat including a common output lead coupled to the transfer medium.

10. A power transfer system as defined in claim 2, wherein the pressure transducer includes:

a combination coil and magnet in relative movable relationship;

a head plate coupled to the combination coil and magnet and being configured to respond directly to the changes in weight of water overhead to vertically displace and induce the relative movable relationship of the coil and magnet for activating a current within the coil; and

restoring means coupled to the head plate for periodically elevating the head plate to a rest position during a trough of the overhead wave in preparation for a following downward displacement responsive to increased weight of water generated by a following wave crest.

11 . A power transfer system as defined in claim 10, further comprising a secondary plate movably coupled with the head plate and being configured to amplify any vertical displacement of the head plate with increased displacement of the secondary plate with an attendant increased current output from the coil.

12. A power transfer system as defined in claim 11, further including:

a compression chamber bounded at an upper opening by the movable head plate;

the secondary plate forming a movable surface which is coupled at one side to the compression chamber and movably positioned at an opposing side within a conversion chamber of lesser diameter than the compression chamber and along an axial orientation of displacement;

said compression chamber having a fluid content which transfers force applied to the head plate into the secondary plate in response to displacement of the head plate and causes a volume displacement of the secondary plate within the conversion chamber;

said secondary plate having a lesser surface area than the head plate to cause increased linear displacement of the secondary plate as compared with displacement of the head plate;

said secondary plate being coupled to the combination of coil and magnet to translate said linear displacement into relative movement of the coil and magnet to generate the current within the coil.

13. A power transfer system as defined in claim 11, wherein the secondary plate comprises a rotary plate coupled to a generator at a rotational axis, said system further including intermediate power transmission structure for translating vertical displacement of the head plate into rotational displacement of the rotary plate.

14. A power transfer system as defined in claim 1, wherein the pressure sensing structure comprises a combination of magnet and coil which are positioned to develop an interacting relationship within a magnetic field of the magnet and with respect to the coil, the combination of magnet and coil being movable with respect to each other in response to the changing height and weight of water to thereby generate an electrical current within the coil, said coil being coupled to the power transfer system for delivering the electrical power output.

15. A power transfer system as defined in claim 1, wherein the pressure sensing structure includes:

a combination of magnet and coil in relative movable relationship for generating current within the coil;

a bellows having a movable plate and a stationary plate and a sealed compression chamber there between, said movable plate being coupled to the

combination of magnet and coil and including a power transmission structure to translate plate movement to the relative movement of the magnet and coil;

said movable plate being depressable by an increased column height of water over the movable plate and including a restoring means for elevating the movable plate to a raised, rest position in response to lesser overhead water to generate a pumping action.

16. A power transfer system as defined in claim 1, wherein the power transmission structure includes a lever arm coupled at one end to the pressure sensing structure and at a remaining end to the combination of magnet and coil and including a fulcrum point which provides an increased range of motion for the combination magnet and coil as compared to the end coupled to the pressure sensing structure to increase a range of motion of relative movement between the coil and magnet.

17. A power transfer system as defined in claim 10, wherein the coil is in fixed position and the magnet moves with respect to the coil.

18. A power transfer system as defined in claim 10, wherein the magnet is in fixed position and the coil moves with respect to the magnet.

19. A power transfer system as defined in claim 1, wherein the pressure sensing structure includes:

a housing;

a head plate movably positioned at the top of the housing, said head plate being supported in a movable configuration responsive to changing weight of overhead water based on the wave motion;

a spring mechanism coupled to the head plate for restoring the head plate upward following depression in response to an overhead wave; and

a combination magnet and coil interactively coupled to the head plate and within an attendant magnetic field such that movement of the head plate results in relative movement between the magnet and coil within the magnetic field to generate current within the coil.

20. A power transfer system as defined in claim 17, wherein the coil also comprises the spring mechanism for providing the resistive force, said magnet being supported within an internal volume of the coil and operable to generate a

current within the coil based upon depression of the coil by the overhead wave and concurrent movement of the magnet within the coil.

21. A power transfer system as defined in claim 1, including:

a base plate;

at least one permanent magnet having a plate-like configuration;

a spring mechanism positioned below the magnet and supported by the base plate, said spring mechanism providing a resistive force to support the magnet below a column of water; and

a conductive coil positioned around the magnet and within an attendant magnetic field;

the magnet, coil and spring mechanism be positioned and supported at the base plate to provide oscillating relative movement of the magnet with respect to the coil to generate an electrical current in response to overhead wave action.

22. A method for converting recurring wave movement within the ocean to useful energy, said method comprising the steps of:

a) positioning pressure sensing structure below water level and at an ocean floor location;

b) generating electrical power output from the pressure sensing structure at the ocean floor location by electro-mechanical conversion of gravity force arising from changes in height of water above the pressure sensing structure to electrical current at the ocean floor location; and

c) transferring the electrical power output to a shore location.

23. A method as defined in claim 20, further comprising the step of generating current flow by causing relative movement of a magnet and field coil positioned at the ocean floor in response to changes in weight of overhead water above the pressure sensitive structure.

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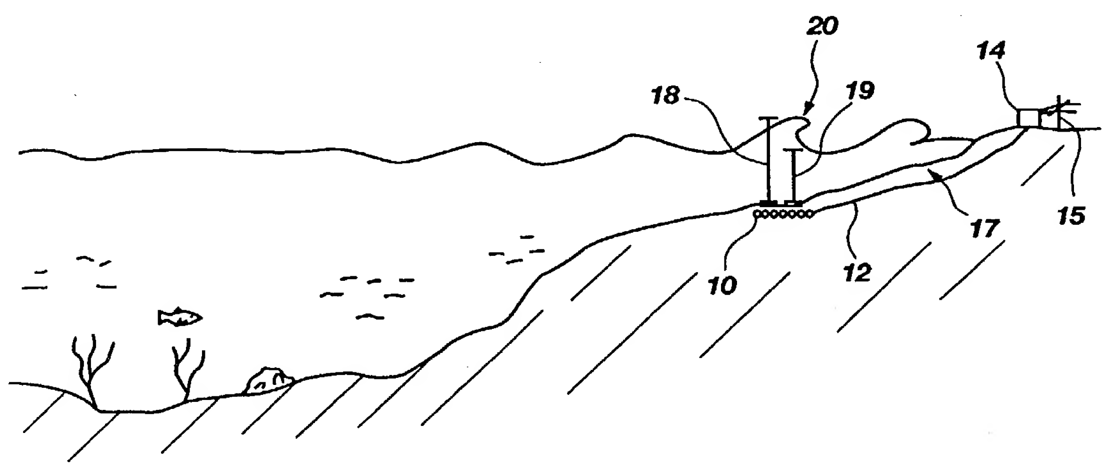

(57) Abstract

A power transfer system for converting recurring wave movement within the ocean to electrical energy. The system comprises pressure sensing structure such as a pressure transducer (10) or combination movable magnet and coil (50), positioned below water level and at a location (20) of wave movement for (i) registering changes in height of water (18 and 19) above the pressure sensing structure (10, 50) and (ii) providing electrical power output corresponding to changes in gravity force associated with the changes in the height of water. A transfer medium (12) is coupled at one end to the pressure sensing structure and extends at a second end to a shore location. A power receiving device such as a bank of storage batteries (14) or electrical load is coupled to the transfer medium at the shore location for receiving the power output from the transfer medium and for processing the power for use.

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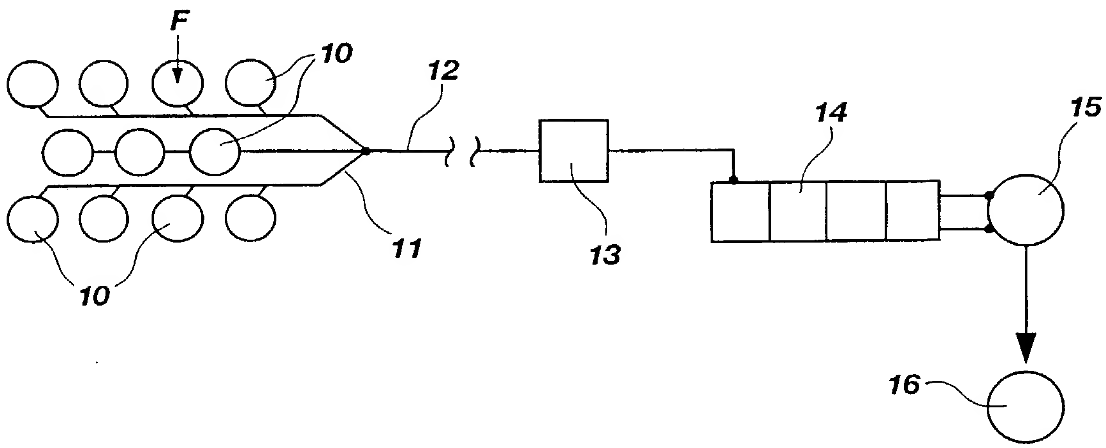


Fig. 1

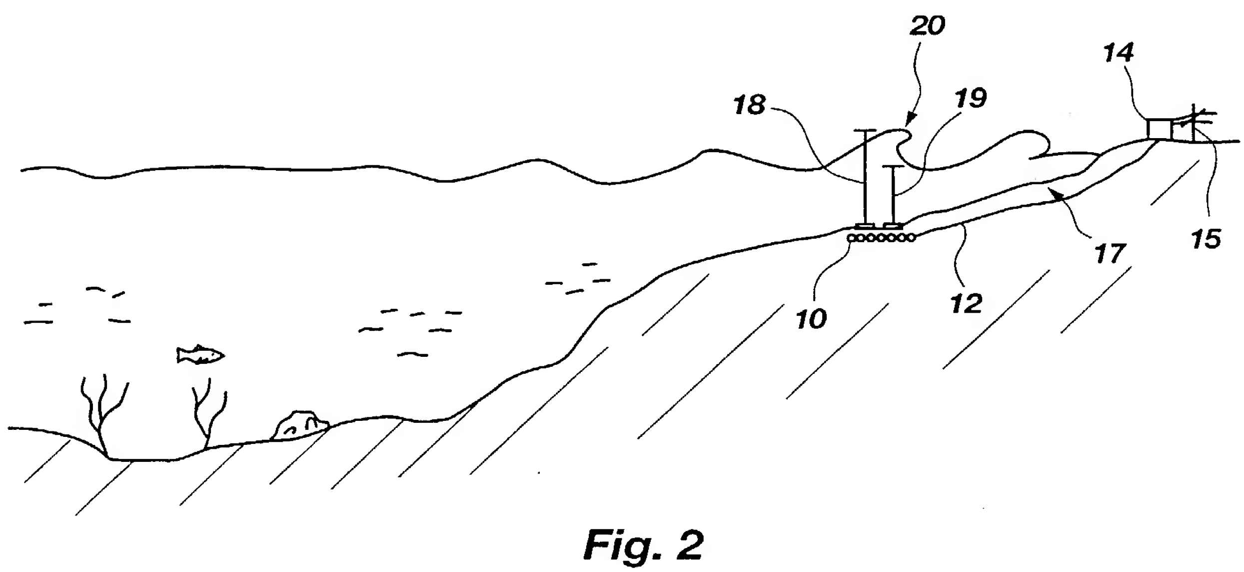


Fig. 2

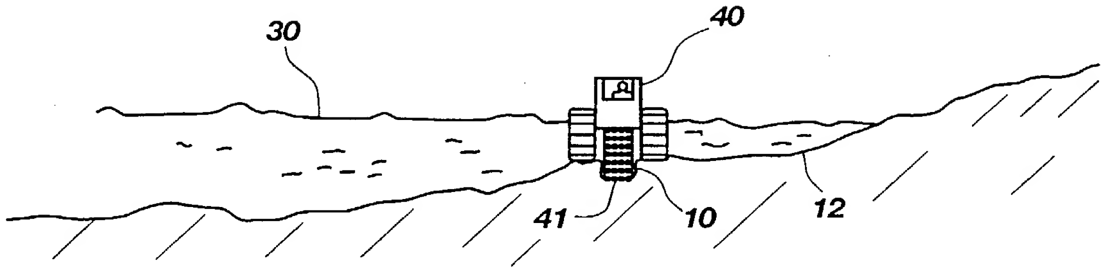


Fig. 3

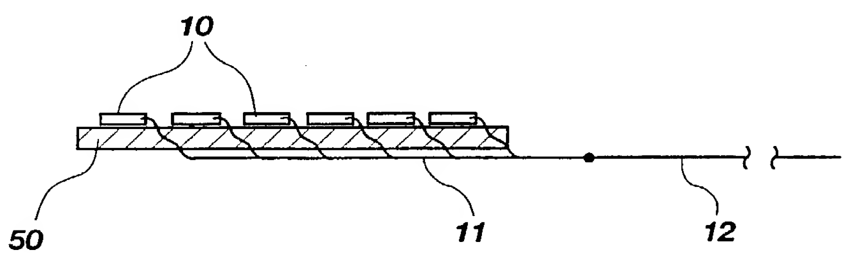
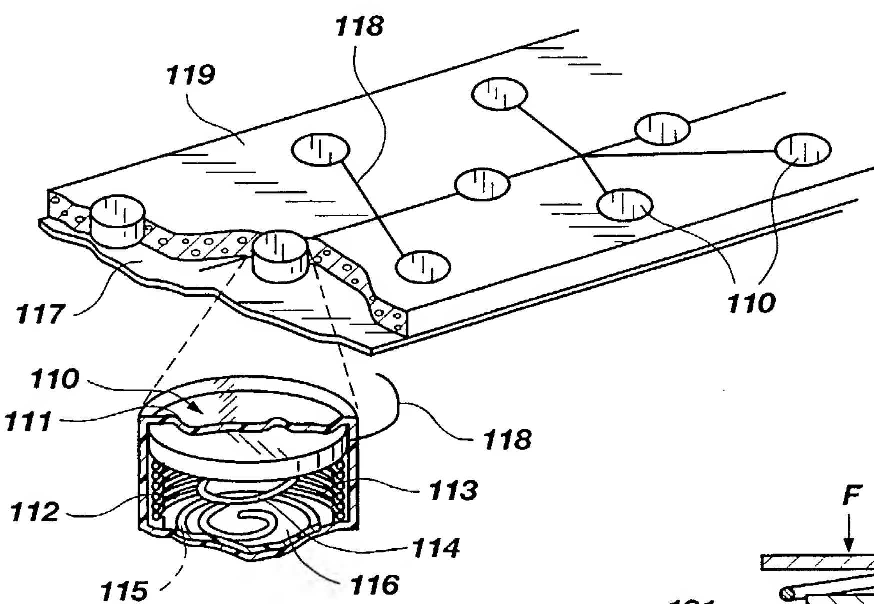


Fig. 4



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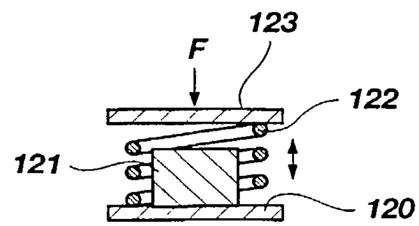

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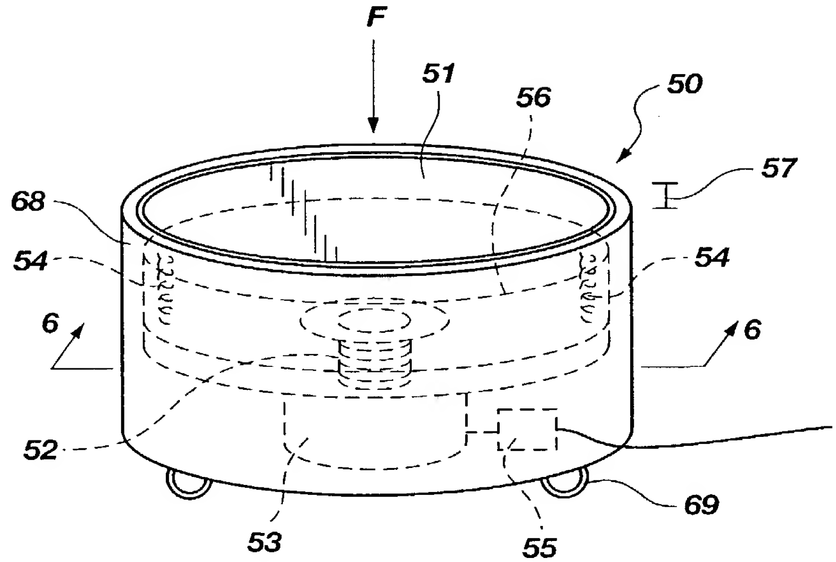

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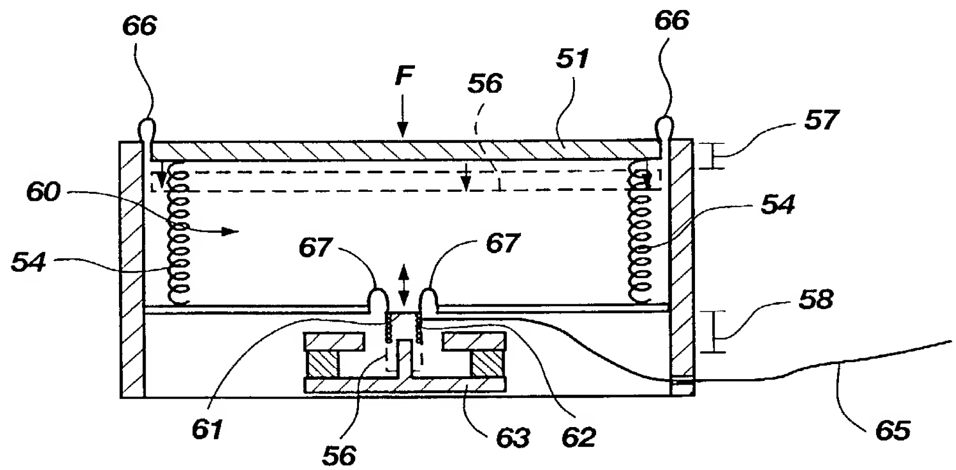

Fig. 6

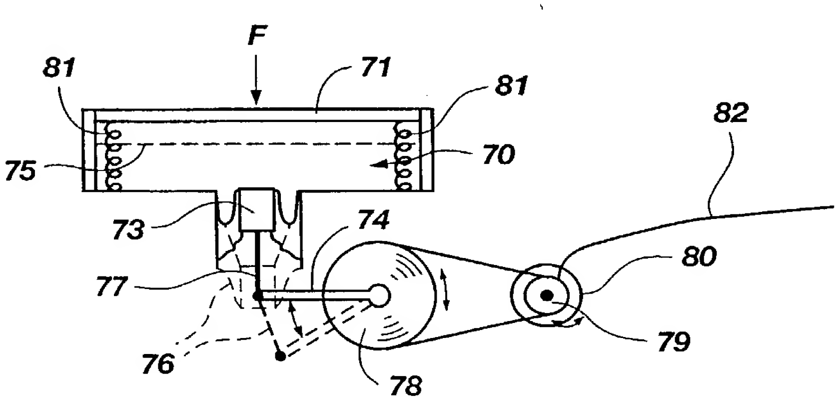

Fig. 7

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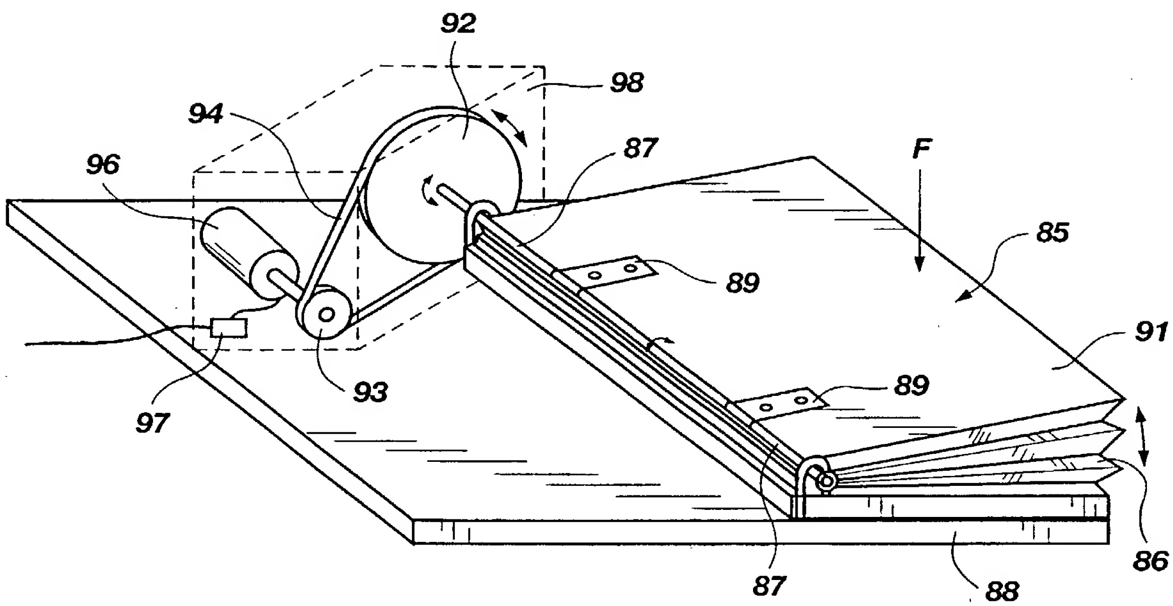
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Fig. 8

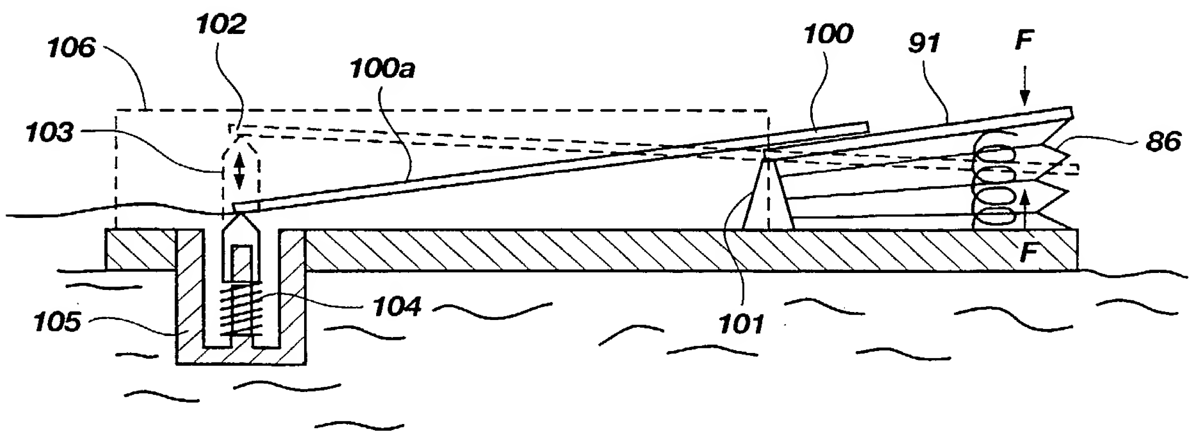
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Fig. 9

PATENT APPLICATION NO 09 646,235
ATTORNEY DOCKET NO. T6637 CIP PCT US

SUPPLEMENTAL DECLARATION AND PETITION

As a below named inventor, I hereby declare: that my residence, post office address, and citizenship are as stated below next to my name; that I verily believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled APPARATUS FOR CONVERTING OCEAN WAVE MOTION TO ELECTRICITY, the specification of which was filed on September 11, 2000 as United States Application No. 09/646,235; that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment specifically referred to above; and that I acknowledge the duty to disclose information which is material to patentability as defined in §1.56(a) of Title 37 of the Code of Federal Regulations.

I hereby claim the benefit under Section 120 of Title 35 of the United States Code of the earlier filed PCT application number PCT/US99/05710 filed on March 15, 1999 with priority date of March 13, 1998; and, insofar as the subject matter of each of the claims of these applications is not disclosed in the earlier filed pending applications in the manner provided by the first paragraph of Section 112 of Title 35 of the United States code, we acknowledge the duty to disclose material information, as defined in Section 1.56(a) of Title 37 of the Code of Federal Regulations, which occurred between the filing date of the earlier filed applications and the filing date of this application.

I declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful, false statements and the like so made are punishable by

PTO/PCT Rec'd 14 DEC 2000

Attorney Docket No. T6637.CIP.PCT.US

POWER OF ATTORNEY

Vaughn W. North, a citizen of the United States of America, residing in Salt Lake City, Utah with an address of 8180 South 700 East, Suite 200, Sandy, Utah 84070-0562, owner of all right, title and interest in the invention entitled APPARATUS FOR CONVERTING OCEAN WAVE MOTION TO ELECTRICITY for which an application for United States Letters patent was filed on September 11, 2000, and given U.S. Patent Application Serial No. 09/646,235, and empowered to prosecute the U.S. and foreign applications on behalf of the inventors, hereby appoint as his attorneys and/or patent agents the law firm of THORPE, NORTH & WESTERN, LLP, having a business address of 8180 South 700 East, Suite 200, Sandy, Utah 84070, and VAUGHN W. NORTH, Registration No. 27,930, M. WAYNE WESTERN, Registration No. 22,788, CLIFTON W. THOMPSON, Registration No. 36,947, GARRON M. HOBSON, Registration No. 41,073, WEILI CHENG, Registration No. 44,609, DAVID R. MCKINNEY, Registration No. 42,868, STEVE M. PERRY, Registration No. 45,357, GARY P. OAKESON, Registration No. 44,266, and DAVID W. OSBORNE, Registration No. 44,989, all with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

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Dated this 4 day of December 2000 at Sandy, Utah.

Vaughn W. North

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fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code, and that such willful, false statements may jeopardize the validity of the application or any patent issuing thereon.

Wherefore, I pray that Letters Patent be granted to me for the invention or discovery described and claimed in the foregoing specification and claims, declaration, and this petition.

Signed at Sandy, Utah, this 12th day of February 2001.

100

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STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(b))--INDEPENDENT INVENTOR	Docket Number (Optional) T6637.CIP.PCT US

Applicant, Patentee, or Identifier: Vaughn W. North

Application or Patent No.: ____

Filed or Issued: September 11, 2000

Title: APPARATUS FOR CONVERTING OCEAN WAVE MOTION TO ELECTRICITY

As a below named inventor, I hereby state that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees to the Patent and Trademark Office described in:

- [X] the specification filed herewith with title as listed above.
- [ ] the application identified above.
- [ ] the patent identified above.

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Separate statements are required from each named person, concern, or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

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Vaughn W. North NAME OF INVENTOR	NAME OF INVENTOR	NAME OF INVENTOR
Vaughn W North Signature of inventor	Signature of inventor	Signature of inventor
Sep 11, 2000 Date	Date	Date

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